Heavy Metal Contamination In Soil Under The Application Of Polluted Sewage Water Across Vrishabhavathi River

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Abstract

The main aim in this study is to assess the level of heavy metals concentration in soil profile and their mobility in the presence of pH and organic carbon ,where polluted water is used in agriculture. The samples of soil collected at different sites across Vrishabhavathi river valley have been analyzed for heavy metals, viz. Pb, Zn, Cd, Cr, Cu, Ni, Fe and Mn using atomic absorption spectrophotometer. These values assessed with respect to reference soil taken from unpolluted soil profile. The heavy metals studied at all sampling sites compared with Indian Standards and all heavy metals are below permissible limits. The concentration of all the metals is high compared to the soil sample taken from unpolluted site shows the build up of heavy metal concentration using polluted water in irrigation. The % of organic carbon varies from 1.9 to 2.9 % in top layer and 1 to 1.6 % in the subsequent layer. The pH value is higher on top layer soil and decreases in subsequent layer.

Keywords: Heavy metals, Soil, Sewage water.

Introduction

The industrial and municipal sewage waste water is mainly used for the irrigation of crops in major metropolitan cities because of cost and non availability of fresh water [1, 2]. Application of sewage water and sludge to agricultural soil is a common practice due to easy availability in periurban ecosystem. Heavy metal transfer is rapid in soil profiles and they can pollute ground water supplies also. The soil is like a reservoir for contaminants as it possesses an ability to bind various chemicals and different forces keep them bound to soil particles. The excessive accumulation of heavy metals in agricultural soils through waste water irrigation contaminates soil profile and in turn it affects the serious problems in food chain contamination because of potential accumulation and bioaccumulation [3]. The areas where no alternative sources of clean water exist, people uses waste water generated by industrial effluents and sewage (treated and untreated) water for irrigation of agricultural lands to increase the production of crops. It has been reported that sewage from municipal origin contains major essential plant nutrients and heavy metals [4]. The fertility levels of the soil are improved considerably using waste water irrigation [5-7]. Heavy metals are generally not removable even after the treatment by sewage treatment plants, causes heavy metal contamination of the soil and subsequently to food chain [8-10]. If these metals move too rapidly in particular soils, they can also pollute ground water supplies, especially in higher water table areas. Movement of heavy metal is higher where sewage waste is disposed on sandy, acidic and low organic matter soils, receiving high rainfall or irrigation water [11].This technical paper mainly focuses on heavy metal soil contamination along Vrishabhavathi river valley where waste water is continuously used for irrigation of crops.

Materials and Methods

Study area

Bangalore is located at a latitude 12.58'N and longitude of 77.35'E at an altitude of 921 m above mean sea level [12]. Vrishabhavathi river is one of the tributaries of the river Cauvery. It carries largest drainage watersheds out of three viz., Vrishabhavathi(1) , Bellandur(2) and Nagavara(3) watersheds as shown in fig 1. The Vrishabhavathi watershed carries polluted effluents of two major industrial areas viz. Peenya and Rajajinagar and domestic sewage effluents (both treated and untreated) directly discharged into it from a large part of city. It also carries Industrial effluents along Bangalore-Mysore State Highway factories and Bidadi Industrial area. This sewage water is used for irrigation along the banks of Vrishabhavathi river valley for about forty five kilometres from its origin.

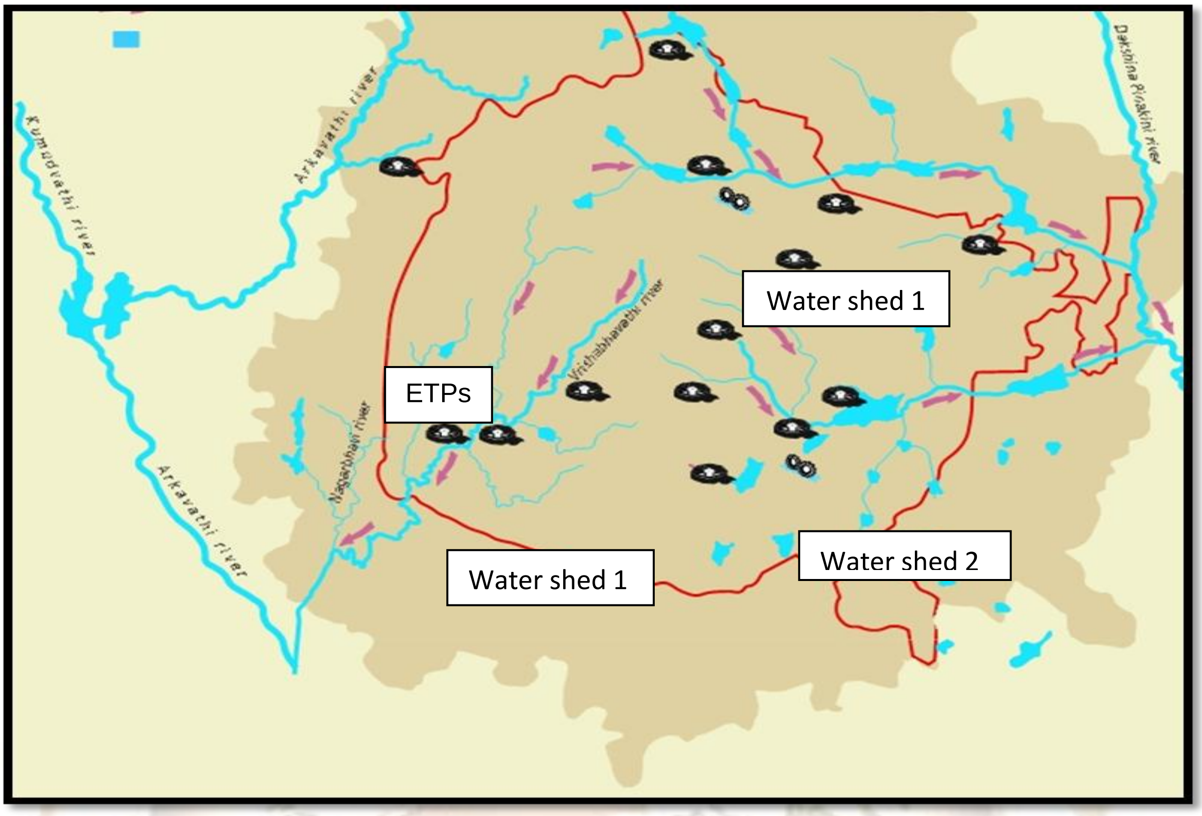


Fig.-1. The three drainage water sheds of Bangalore(Source: Anon 2011, 71-City Water-Excreta Survey, 2005-06, Centre for Science and Environment, New Delhi)

Sampling and Analysis

The sampling sites were chosen to study heavy metal contamination in soil, where the sewage water is directly used for agriculture purpose from past several years. Seven sites were identified at different sites along Vrishabhavathi river valley and the sites were shown in fig. 2 during the year 2009. The surface soil sample up to depth 25 cm is collected, since the most of the heavy metal retains in top layer with respect to soil factors [13].Large stones and plant materials were removed. The pH of the soil was determined with the ratio, Soil: Water,1:5 wt/vol. using water analyser 371 systronics. The organic carbon was determined by titrimetric method of Walkley and Black method [14]. The samples dried for three days at about 50^{o}C, grinded well using pestle and mortar and sieved through 1mm nylon mesh. The soil sample of 1gm from sieved soil is digested in 10 cm^3 of 1:1 mixture of concentrated nitric acid and hydrofluoric acid till all the black residue turns colourless at about 200^{o}C in fuming chamber. The samples were redissolved in dilute hydrochloric acid filtered through Whatman no.42 filter paper with repeated washing with distilled water and the filtered sample is diluted up to 100ml using distilled water [13]. The samples were analyzed for heavy metals using Atomic Absorption Spectrophotometer (GBC Avantra Version1.31)

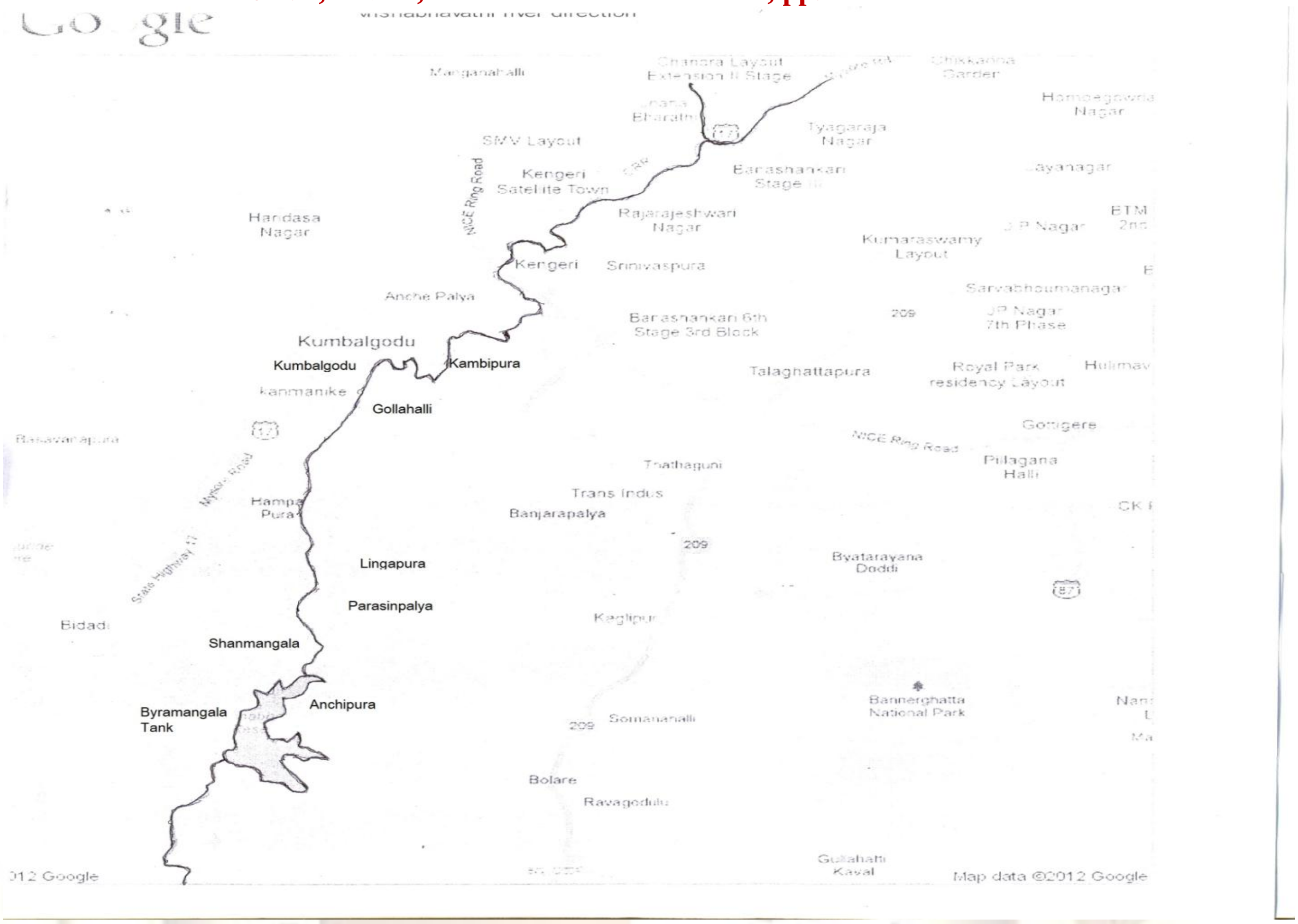


Fig 2. Location map of sample sites acrossVrishabhavathi river Site no. 1 kambipura , Site no. 2 kumbalgodu, Site no. 3 Gollahalli , Siteno. 4 LingapuraSite no. 5 Parasinpalya , Site no. 6 Shanmangala , Site no. 7 Anchipura

Results and Discussion

The data analysed for polluted soil and one sample from unpolluted soil is represented in Table 1and the concentration of heavy metals at different sites is represented in fig.3. The heavy metal concentration increases by the application of polluted sewage water continuously in irrigation due to leaching of heavy metals [15]. Higher concentration of metals were detected in the top layer up to 15 cm depth and decreases in the next layer up to 25 cm [16].

The pH of the soil is near neutral at all sites. The pH is maximum of 7.5 at site number 6, and minimum pH 6.6 at site number 4. The organic carbon varies from 1.9 to 2.9% in top layer and 1.0 to 1.6 % in the subsequent layer across the study sites. The soil organic carbon is the not only provides sorption site for metals directly, it will also combine with soil minerals and increases the sorption sites [17].The concentration range is sufficient to retain certain metals within 30 cm depth [18].

Near neutral pH more complexation of heavy metals takes place with organic carbon resulting in their accumulation in the top layers [19, 20]. The solubility is low for Pb, Zn, Cd and Cu at pH 6 to 6.5 and an increase by several orders at lower pH values and in alkaline solution exhibited weak solubility [21, 22].

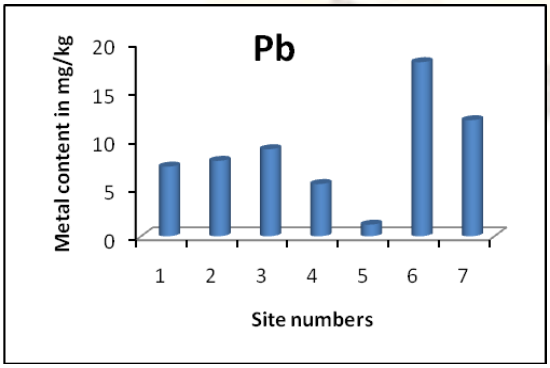
Pb is higher18 mg/kg at site no.6 and lowest 1.2 mg/kg at site no.5 decreases with depth at all sites. Cd is below detectable range in all sites. Zn is high at site no.6, 54 mg/kg and minimum at site no.3, 15.6 mg/kg and decreases with depth. Ni is maximum at site no.6, 24.6 mg/kg, similarly at site no. 5 & 7,19.2 &18 mg/kg respectively. Concentration decreases in depth of 25 cm. Cu concentration is maximum 31.8 mg/kg at site no.6 and lowest 0.6 mg/kg at site no.3. The concentration is high at site no.5, 21.6 mg/kg and site no.7 16.8 mg/kg. Cr metal is maxima at site no.6, 30.6 mg/kg and minima at site no.4, 0.6 mg/kg. It is also higher at site site no.5, 24 mg/kg and 12.6 mg/kg at site no.7. Fe metal concentration is higher among all other metals, the concentration varies from 126 mg/kg to 234 mg/kg in top layer and 65 to 125 mg/kg in the subsequent layer. Mn metal concentration is higher at site no.3, 72 mg/kg and at site 2, 60 mg/kg.

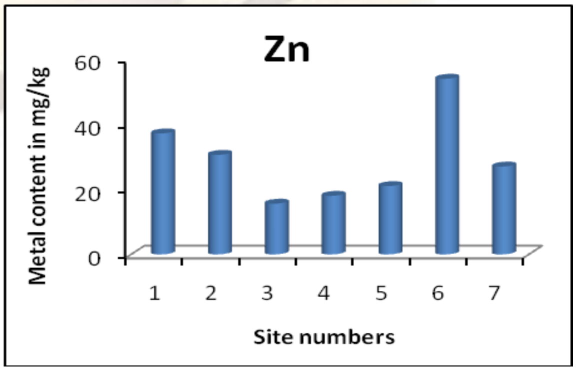
The variation in the heavy metal concentration in soil at different sites is due to variation in heavy metal sources and concentration of heavy metals present in polluted water where the water is used continuously for irrigation for several years. The soil pollution also takes place due to atmospheric fall out, emissions from vehicular exhaust, land application of municipal solid waste, sewage sludge, fertilizers, pesticides etc. [23] Hence the metal concentration is high in this area compared with unpolluted area. The heavy metals studied at all sampling sites compared with Indian Standards [24] and all heavy metals are below permissible limits. The concentration of all the metals is high compared to the soil sample taken from unpolluted site (table 1) shows the build up of heavy metal concentration using polluted water in irrigation.

Table 1: pH, % of Organic Carbon and Heavy metal concentration in soil(mg/kg) along Vrishabhavathi river valley.

Site no.	Depth cm	Site-1	Site-2	Site-3	Site-4	Site-5	Site-6	Site-7	Unpolluted soil sample
pH	0-15	6.9	7.0	7.0	6.6	7.1	7.5	7.2	6.5
	15-25	5.5	6.4	6.3	6.0	6.5	6.8	6.5	6.1
OC	0-15	2.5	2.6	2.9	1.9	2.3	2.5	2.1	1.1
	15-25	1.2	1.4	1.6	1.0	1.2	1.3	1.1	0.4
Pb	0-15	7.2	7.8	9	5.4	1.2	18	12	4
	15-25	3.6	4.0	4.6	3.1	0.6	10	09	1.2
Cd	0-15	nd	nd	nd	nd	nd	nd	nd	nd
	15-25	nd	nd	nd	nd	nd	nd	nd	nd
Zn	0-15	37.2	30.6	15.6	18	21	54	27	20
	15-25	20.3	16.3	8.2	10	12	25	12	9
Ni	0-15	4.8	3	5.4	6	19.2	24.6	18	nd
	15-25	2.3	1.6	3.0	4.0	10.1	12	10	nd
Cu	0-15	5.4	3	0.6	9	21.6	31.8	16.8	5
	15-25	3.0	1.7	0.4	4.1	10.2	16.9	10	2
Cr	0-15	1.2	3	2.4	0.6	24	30.6	12.6	0.9
	15-25	0.8	1.8	1.1	0.4	13	16	10	0.2
Fe	0-15	126	150	186	180	199.2	234	180	280
	15-25	65	80.2	96	89	96.5	125	86	252
Mn	0-15	30.6	60	72	28.8	30.6	21	18.6	12
	15-25	16.2	34	36	20	18.2	10	08	4

Nd-not detected





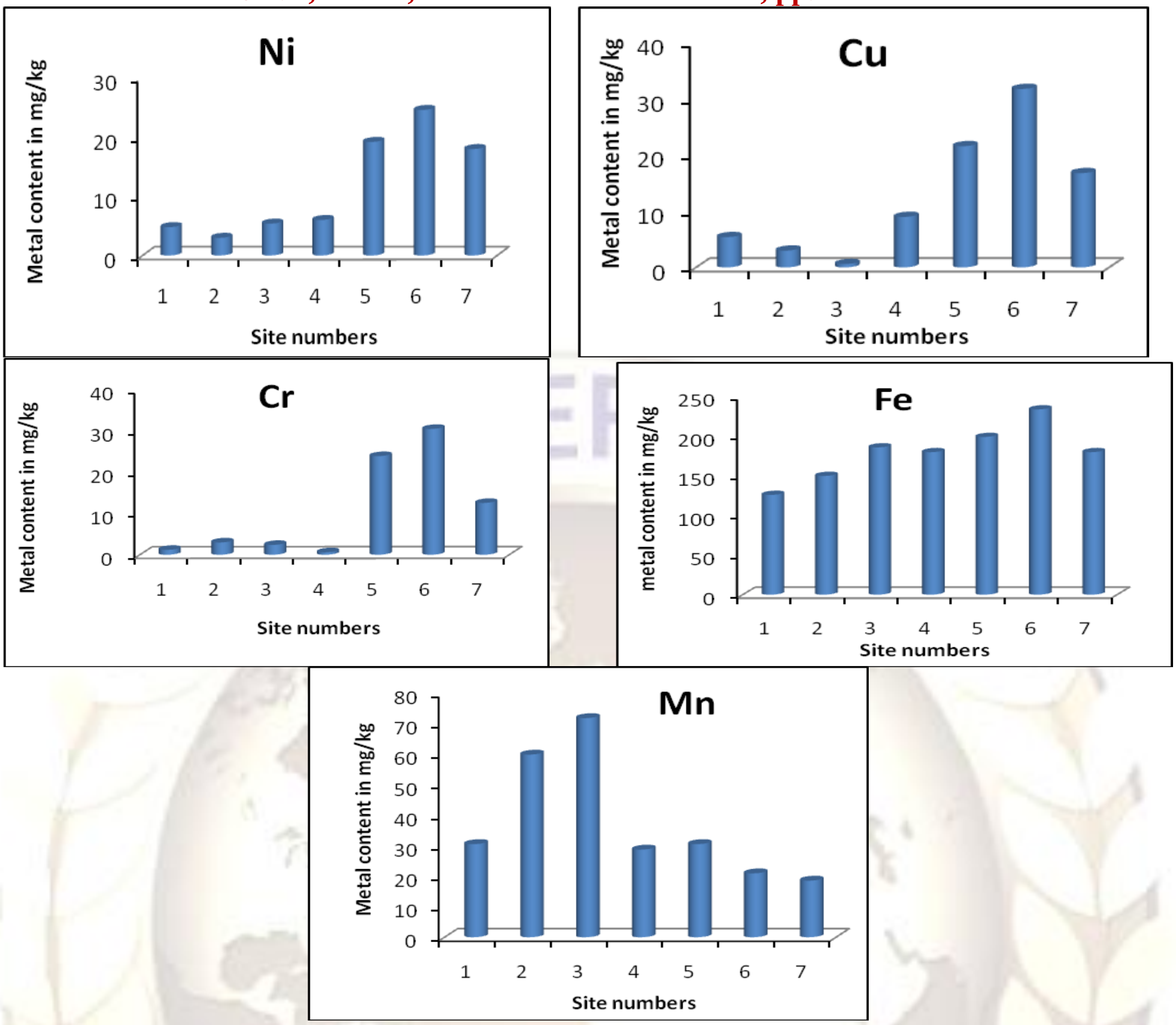


Fig 3. Total metals concentration in top layer soil (up to 15 cm depth) at different sample sites.

Conclusion

The study reveals that the irrigation with polluted water containing variable amount of heavy metal increases the concentration in soil samples. The heavy metals studied at all sampling sites compared with Indian Standards and all heavy metals are below permissible limits. The concentration of all the metals is high compared to the soil sample taken from unpolluted site shows the build up of heavy metal concentration using polluted water in irrigation. The presence of heavy metals in soil is one of the key components of human exposure to metals through the food chain. The heavy metals can be removed by plants and it is an effective method in cleaning up of contaminated soil. The presence of heavy metals has merit attention especially for developing countries where newly establishing industries and extensive urban growth continue to raise heavy metals in soil.

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